**Scholars Journal of Applied Medical Sciences**
Abbreviated Key Title: Sch J App Med Sci
ISSN 2347-954X (Print) | ISSN 2320-6691 (Online)
Journal homepage: https://saspublishers.com

OPEN ACCESS

**Anatomy**

# Morphometric Measurements of the Superior Sagittal, Transverse and Sigmoid Dural Venous Sinuses in Normal Cerebral MRV Images of Adult Bangladeshis

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**DOI:** 10.36347/sjams.2022.v10i03.030 | **Received:** 16.02.2022 | **Accepted:** 24.03.2022 | **Published:** 31.03.2022

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**Abstract** **Original Research Article**

***Background*:** The dural venous sinuses show different types of morphometric variations in their anatomy as well as involvement with various neurological conditions like cerebral venous sinus thrombosis, venous sinus stenosis, embolism, fistula etc. Cerebral MRV (Magnetic Resonance Venography) is a well-established radiological technique to visualize the dural venous system. By measuring the sinus dimensions in cerebral MRV images and calculating the indices, morphometric variations of the dural venous sinuses can be identified which is essential for diagnosing different pathologies of the dural venous system. Researcher have detected most of the variations in the superior sagittal, transverse and sigmoid venous sinuses. ***Objectives:*** To develop anatomical baseline data on morphometric measurements of the dural venous sinuses in normal cerebral MRV images of adult Bangladeshis. ***Methods:*** The research was cross-sectional and observational in nature. It was carried out in the Department of Anatomy, Bangabandhu Sheikh Mujib Medical University (BSMMU) in collaboration with the Department of Neuroradiology & Imaging, National Institute of Neuroscience and Hospital (NINS), Dhaka, from March 2020 to June 2021. Adults (35 males and 35 females) aged 18 years or above who attended in the Department of Neuroradiology & Imaging, NINS for cerebral MRV and diagnosed as having normal dural venous sinuses without any pathology by a registered Neuroradiologist were the participants of this research. The MRV scans were produced by using 3 Tesla magnetic field strength following the routine standard protocols of the institution. By using the Radiant DICOM Viewer software, a total of 9 linear and curvilinear dimensions were measured and 2 indices were calculated by the researcher and the co-investigator independently to reach consensus on each variable. ***Results:*** A numerical data set was generated on the morphometric measurements of the superior sagittal, transverse and sigmoid sinuses of the adult Bengali Bangladeshis. When compared with the data from other populations, these data showed some similarities and some differences. The mutually relevant measurements and indices are presented in tables and textual descriptions as readily comprehensible material. ***Conclusion:*** It can be concluded that the finding of this study may will be helpful in the appropriate diagnosis and treatment planning of the dural venous sinus diseases as well as in applied anatomical education.

**Keywords:** Magnetic Resonance Venography (MRV), superior sagittal sinus, transverse sinus, sigmoid sinus, dimensions, indices, variations.

# INTRODUCTION

The dural venous sinuses are venous channels located between the two layers of the dura mater in the brain. They are also called cerebral sinuses or cranial sinuses. They collect blood from internal and external veins of the brain, receive cerebrospinal fluid (CSF) from the subarachnoid space via arachnoid granulations and then subsequently drain into the internal jugular veins. The superior sagittal, transverse and sigmoid sinuses are included in the superior group of dural venous sinuses that drain a major part of the brain and cranial vault [1].

The sinuses are important anatomically because variations in morphometric measurement and morphology is common [1, 2]. The morphometric measurements of the dural venous sinuses also show variations in some pathological conditions like dural venous sinus thrombosis, intracranial hypertension or hypotension, arteriovenous malformations, intracranial tumor, hemorrhages etc [3]. Apart from clinical conditions, diameters of the dural venous sinuses are also considerably affected by the drainage pattern. For example, diameters of transverse sinuses are directly proportional with drainage pattern of the superior sagittal sinus. It is larger in that site in which the superior sagittal sinus is dominantly drained [4]. The right sigmoid sinus is a continuation of the right transverse sinus, but interestingly its diameter increases proportionately with the diameter of the left transverse sinus. The length and diameter of the sigmoid sinuses are directly proportional to each other [5]. These are some normal variations found in the anatomy of the dural venous sinuses which are detected through the morphometric measurements of the dural venous sinuses in previous studies.

Moreover, to identify the common normal morphological variations of the dural venous sinuses termed as hypoplasia, symmetry between the paired sinuses etc., measurement of the sinuses is essential. To determine the hypoplasia of the transverse or sigmoid sinus, the diameter of the respective sinuses is compared either with the diameter of the superior sagittal sinus or with the diameter of each other [6, 7, 12]. The symmetry between the paired dural venous sinuses can be determined by calculating asymmetry index but for this calculation measurement of diameter is must.

Among all dural venous sinuses, the superior sagittal, transverse and sigmoid venous sinuses are the commonest sites for cerebral venous sinus thrombosis and other pathologies as well as for anatomical variations [2].

Knowledge about the morphometric measurements of the dural venous sinuses must be put in consideration in diagnosing different types of clinical conditions related to the dural venous sinuses. Different types of invasive and non-invasive imaging modalities such as CT cerebral venography (CTV), cerebral magnetic resonance venography (MRV), digital subtraction angiography (DSA) of the brain is available for the evaluation of the anatomical variants and pathologies of the dural venous sinuses. Among the imaging modalities cerebral MRV is one of the reliable authentic diagnostic methods that is used in current radiological practice for the detection of normal anatomy and pathology of dural venous sinuses [8]. Although many clinical and radiological studies have already been done on dural venous sinuses pathology but study on anatomical measurements of the dural venous sinuses are relatively few. To the best our knowledge, no study has been done regarding the measurement of dural venous sinuses of adult Bangladeshis. So, development of anatomical baseline data on morphometric measurements of the dural venous sinuses in normal cerebral MRV images of adult Bangladeshis is demanded.

# METHODOLOGY

**Type of study**

The research was cross-sectional and observational in nature.

**Study Place**

The research was carried out in the Department of Anatomy, Bangabandhu Sheikh Mujib Medical University (BSMMU) in collaboration with the Department of Neuroradiology & Imaging, National Institute of Neuroscience and Hospital (NINS).

**Study period:** From March 2020 to June 2021.

**Study population**

The participants of the research were the adult Bangladeshis attending in the Department of Neuroradiology & Imaging, NINS for cerebral MRV.

**Sample Size**

A total of seventy 70 (35 males and 35 females) participants were selected for this research.

**Sampling technique**

Seventy (70) adult Bengali Bangladeshis were selected by convenient purposive sampling technique. The patients attending in the Department of Neuroradiology & Imaging of NINS for cerebral MRV, co-operating, physically and psychologically stable (ensured by history taking), consented for participating in the research and who's cerebral MRV reports were normal determined by a registered Neuroradiologist were considered as the sample of this research. The participants were selected by a checklist on the basis of some exclusion and inclusion criteria.

## SELECTION CRITERIA

**Inclusion Criteria**

i) Aged 18 years or above
ii) Bangladeshi by nationality and residence
iii) Male or female by sex
iv) Having radiologically normal cerebral MR venography (MRV) (confirmed by a registered Neuroradiologist)
v) Is willing to participate in the research

**Exclusion Criteria**

Having diagnosed history or suggestive features of any of the following:

i) Cerebral venous sinus thrombosis
ii) Ischemic or hemorrhagic stroke
iii) Congenital or acquired intracranial abnormalities
iv) Intracranial hypertension
v) Intracranial space occupying lesion
vi) Neuro-surgery
vii) Head injury

**MRV imaging**

The routine standard MRV protocols of the Department of Neuroradiology & Imaging, NINS, were followed for each individual participant in this research. MRV imaging were performed with 3-T MRI machine using either 'contrast' or 'non-contrast (phase contrast)' method. The basic parameters of the contrast MRV were: TE = 1.14 ms, TR = 3.09 ms, FOV = 280 mm, slice thickness = 1.40 mm, resolution matrix = 260 x 204, and flip angle = 20 degree. For non-contrast (phase contrast) MRV method following parameters were used: TE = 7.39 ms, TR = 4.56 ms, FOV = 230 mm, resolution matrix = 230 x 229, and flip angle = 15 degree. Post processing of the source images was performed using the maximum intensity projection (MIP) method. The softcopies of the participants cerebral MRV were copied into compact disc (CD-R) and collected for taking the measurements of the superior sagittal, transverse and sigmoid dural venous sinuses.

**MRV Image Analysis**

3D MRV MIP source images were viewed in coronal and sagittal plane for taking the measurements of the respective sinuses. The variables of this research were the diameter (linear dimension) of the superior sagittal, transverse and sigmoid sinuses, the length (curvilinear dimension) of the superior sagittal and transverse sinuses, distance between the transverse-sigmoid junctions and the asymmetry index of the right and left transverse/sigmoid sinuses. The measurements were taken through using of RadiAnt DICOM Viewer [Version no. 2020.1 4/8/2020 (64-bit)] software which is an application for processing and displaying medical images in DICOM (Digital Imaging and Communications in Medicine) format. Each measurement was taken two times by each of the two investigators of this research independently. The average of the obtained values of each author was calculated and then again averaged to get one the final value.

The diameter of the superior sagittal sinus was measured 1 cm curved linear distance from the confluence of sinuses in coronal view (Fig 1) and the length of it was the curvilinear measurement of the superior sagittal sinus from the beginning to the ending of the superior sagittal sinus in sagittal view (Fig 2) [11, 13].

Beginning of the sinus was defined as the most frontal point could be recognized and the end point was defined as the junction of the superior sagittal sinus and the confluence of sinuses.

The diameter of the transverse sinuses was measured 1 cm straight linear distance from the confluence of sinuses (Fig 3) and the length was measured along the middle of the transverse sinus from the bifurcation of the confluence of sinuses to the curvature of the transverse-sigmoid junction (Fig 4) [13, 14].

The diameter of the sigmoid sinuses was the transverse linear measurement of the right/left sigmoid sinus, 1cm curved linear distance from the midpoint of the transverse-sigmoid junction in coronal view (Fig 5) [17].

The distance between the transverse-sigmoid junction was the linear measurement from the inner border of the left transverse-sigmoid junction to the right transverse-sigmoid junction in coronal view (Fig 6). The transverse-sigmoid junction was defined as the site in where transverse sinus ends by its vertical descent [15].

Asymmetry index of the right and left transverse/sigmoid sinuses was calculated by the ratio of the diameters of the right and left transverse sinus [16].

The right and left transverse/sigmoid sinuses were identified as symmetrical if the measurement ratio of the diameters of both transverse/sigmoid sinuses was found equal or between 0.67 to 1.5 [16].

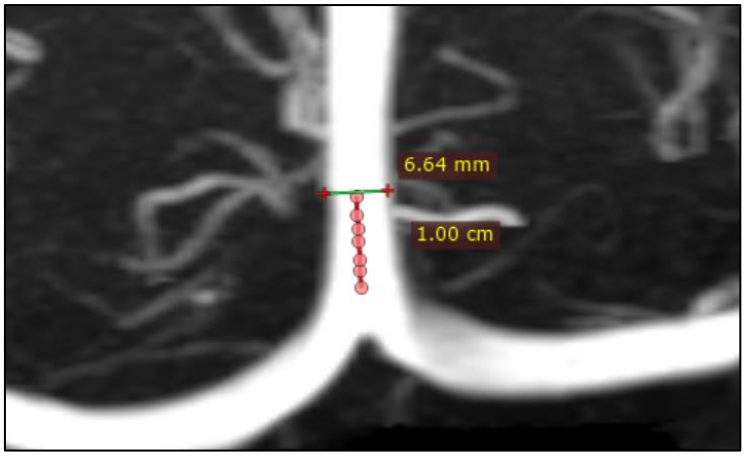


**Fig 1: Coronal view of MRV image showing the measurement of the diameter of the superior sagittal sinus (green line) measured 1 cm distance (red dotted line) from the confluence of sinuses**

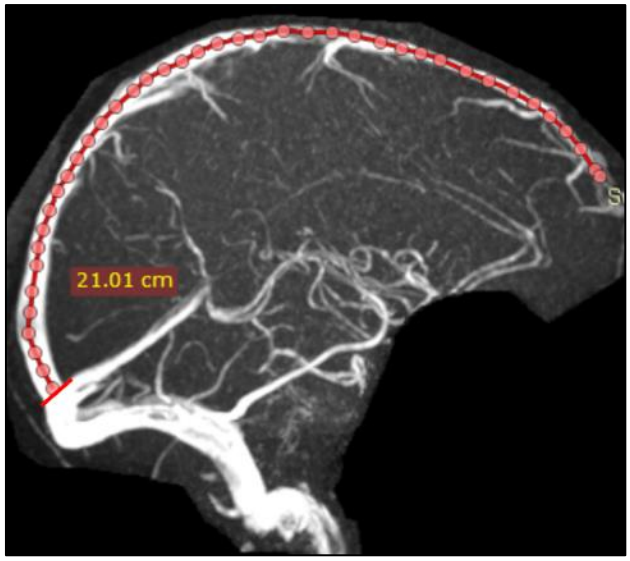


**Fig 2: Sagittal view MRV image showing the length of the superior sagittal sinus (red dotted line)**

The red straight line indicates the junction between the superior sagittal sinus and the confluence of sinuses.

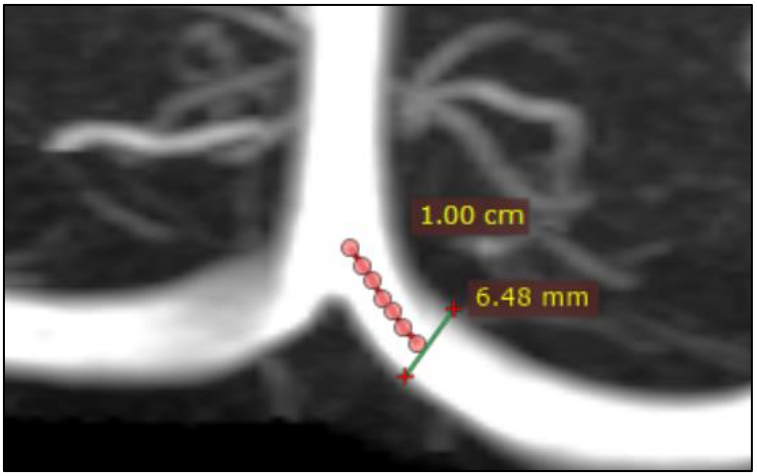


**Fig 3: Coronal view of MRV image showing measurement of the diameter of the right transverse sinus (green line), measured 1 cm away (red dotted line) from confluence of sinuses**

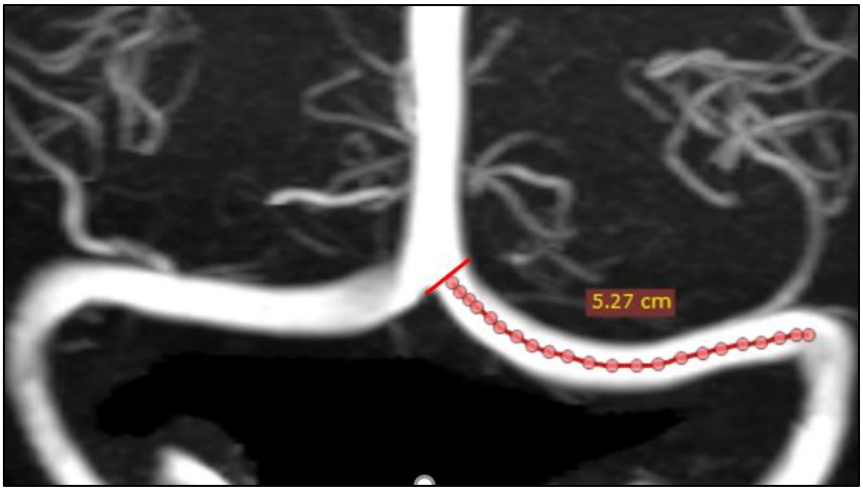


**Fig 4: Coronal view of MRV image showing the measurement of the length of the right transverse sinus (red dotted line)**

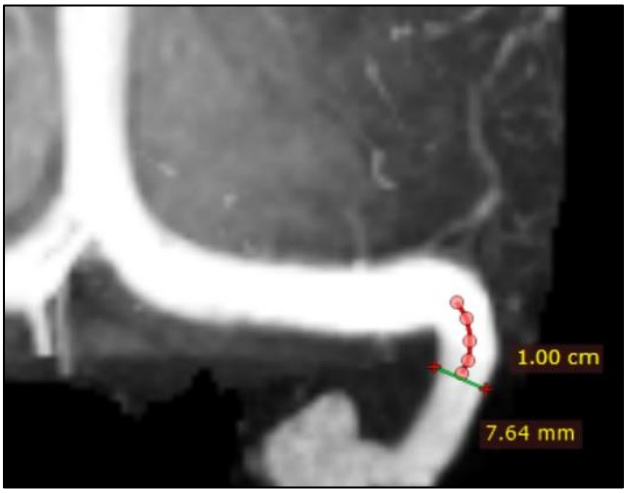


**Fig 5: Coronal view of MRV image showing measurement of the diameter of the right sigmoid sinus (green line), measured 1 cm below (red dotted line) from the midpoint of the transverse-sigmoid junction**

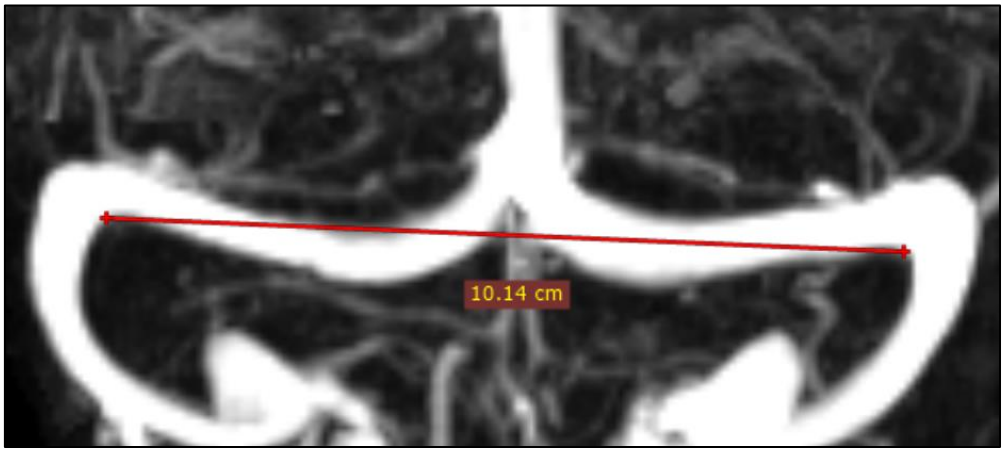


**Fig 6: Coronal view of MRV image showing the measurement of the distance between transverse sigmoid junctions**

### Data processing and analysis

The mutually relevant measurements and indices were presented in tables and textual descriptions as readily comprehensible material.

## RESULTS

According to the described methods and IRB approved protocol 70 adult Bangladeshis (35 males and 35 females) were selected for this research. The mean with standard deviation, median with 25$^{th}$ and 75$^{th}$ percentile, probability (and significance), and 95%

confidence interval of mean were to describe the normative values.

**Dimensions and indices of the superior sagittal, transverse and sigmoid dural venous sinuses**

**Linear and curvilinear dimensions of the superior sagittal sinus**

The mean and median of the linear and curvilinear dimensions of the superior sagittal sinus are shown in Table 1.

**Table 1: Values of the linear and curvilinear dimensions of the superior sagittal sinus (SSS)**

| Dimension | Value<br>Mean ±SD<br>Median (25th and 75th percentile) | | 95% confidence interval of mean | |
|---|---|---|---|---|
| | Male | Female | Male | Female |
| **Linear dimensions (mm)** | | | | |
| Diameter of the SSS | 6.69 ± 1.45<br>6.82 (5.81, 7.79) | 6.69 ± 1.25<br>6.52 (5.90, 7.31) | 6.19 - 7.19 | 6.26 - 7.11 |
| **Curvilinear dimensions (cm)** | | | | |
| Length of the SSS | 21.78 ± 1.36<br>21.69 (20.63, 22.94) | 21.58 ± 1.39<br>21.62 (20.83, 22.64) | 21.32 - 22.25 | 21.11 - 22.06 |

n = 70 (35 in males and 35 in females)

**Linear and curvilinear measurements and index of the transverse sinus**

The mean and median of the linear and curvilinear measurements and calculated asymmetry index of the right and left transverse sinuses are shown in Table 2.

**Table 2: Values of the linear and curvilinear dimensions and asymmetry index of the transverse sinus (TS)**

| Dimension/ Index | Value<br>Mean ±SD<br>Median (25th and 75th percentile) | | 95% confidence interval of mean | |
|---|---|---|---|---|
| | Male | Female | Male | Female |
| **Linear dimensions (mm)** | | | | |
| Diameter of the left TS | 5.95 ± 2.38<br>5.57 (4.16, 8.25) | 6.07 ± 2.30<br>6.20 (4.26, 8.02) | 5.09 - 6.81 | 5.28 - 6.86 |
| Diameter of the right TS | 7.73 ± 2.09<br>7.67 (5.68, 9.40) | 7.24 ± 2.49<br>7.88 (4.97, 9.31) | 7.01 - 8.45 | 6.38 - 8.09 |
| **Curvilinear dimensions (cm)** | | | | |
| Length of the left TS | 4.93 ± 0.72<br>4.84 (4.48, 5.38) | 4.79 ± 0.53<br>4.79 (4.44, 5.18) | 4.67 - 5.19 | 4.61 - 4.97 |
| Length of the right TS | 4.62 ± 1.03<br>4.55 (4.04, 4.96) | 4.56 ± 0.58<br>4.55 (4.15, 4.87) | 4.27 - 4.97 | 4.36 - 4.76 |
| **Index** | | | | |
| Asymmetry index of the right and left transverse sinuses | 1.55 ± 0.81<br>1.20 (1.04, 2.09) | 1.41 ± 0.77<br>1.19 (0.83, 2.11) | 1.26 - 1.85 | 1.14 - 1.68 |

**Linear measurements and index of the sigmoid sinus**

The mean and median of the linear measurements and calculated asymmetry index of the right and left sigmoid sinuses are shown in Table 3

**Table 3: Values of the linear dimensions and asymmetry index of the sigmoid sinus (SS) with comparisons between males and females**

| Dimension | Number of total participants (n) | | Value<br>Mean ±SD<br>Median (25th and 75th percentile) | | 95% confidence interval of mean | |
|---|---|---|---|---|---|---|
| | Male | Female | Male | Female | Male | Female |
| **Linear dimensions** | | | | | | |
| Diameter of the left SS (mm) | 34 | 35 | 5.46 ± 1.49<br>5.28 (4.10, 6.49) | 5.82 ± 1.39<br>5.65 (4.69, 7.00) | 4.93 - 5.98 | 5.34 - 6.29 |
| Diameter of the right SS (mm) | 35 | 35 | 6.90 ± 1.12<br>7.14 (6.11, 7.56) | 7.00 ± 1.61<br>7.17 (5.69, 8.17) | 6.52 - 7.29 | 6.45 - 7.55 |
| Distance between transverse sigmoid junction (cm) | 34 | 35 | 9.35 ± 0.61<br>9.51 (8.94, 9.72) | 9.12 ± 0.59<br>9.09 (8.64, 9.58) | 9.13 - 9.57 | 8.92 - 9.32 |
| **Index** | | | | | | |
| Asymmetry index of the right and left sigmoid sinuses | 34 | 35 | 1.39 ± 0.52<br>1.20 (0.99, 1.73) | 1.29 ± 0.46<br>1.27 (0.90, 1.62) | 1.21 - 1.58 | 1.14 - 1.45 |

# DISCUSSION

**General Discussion**

In this research, some confusion raised during taking measurements because of variations in the measurement landmark and modalities of taking measurements in the previous studies. Here all the measurements have been taken following the authors mentioned in the methodology, who have notified an absolute point of measurement in their studies. Moreover, each measurement was taken two times by the researcher and the co-investigator independently to eliminate observer bias and inter-rater reliability test was done between the average values of the two investigators for each measured dimension. The inter-rater correlation coefficient was > .85 (higher reliability). Expert opinion was also been taken from the Consultant Neuroradiologist of the Department of Neuroradiology & Imaging, NINS, when any confusion raised regarding MRV technique or measurement procedure.

**Discussion On Result**

In the present research the mean values of the dimensions and indices were compared with the mean values of the other available studies, as the detailed data of different studies were not available. If the mean values of the other studies were within the mean ± 2% of the mean values of the present study, then the values were considered as 'similar' [18].

**Discussion on the dimensions of the superior sagittal sinus**

In the present research, the mean value of the length of the superior sagittal sinus showed dissimilarity with the results of two studies done on Indian population who have found the length of the superior sagittal sinus as 25.74 cm and 26.09 cm respectively [5, 9]. As both these studies as well as the present study have been done in the Indian subcontinent, so similarities in the findings were expected. But dissimilarity might be due to variations in the modality of the study and measurement procedure. It is mentionable that, the length of the superior sagittal sinus has been found longer in cadaver-based studies by some researchers than the imaging-based studies except Brockmann *et al*., (2012) who measured the length both in cadaver and CTV images but their length measurement in the cadaver had found notably shorter than the measurements in CTV images [11]. Interestingly, the length measured in CTV images have shown more similarity with the measured length in dry skull but longer than measured length in MRV images in the present research [11, 5, 10]. Although in the present research, the superior sagittal sinus's length was measured following the landmarks of Brockmann *et al*., (2012), dissimilarity with them may provide a hint that morphometric measurement of the dural venous sinuses can vary with imaging modality [11].

The mean value of the diameter of the superior sagittal sinus in the present research is lower than the mean values of the other available literature done on MRV image but higher than the measured diameter in CT angiographic images [7, 19] Furthermore, measured diameter of the superior sagittal sinus in dry skull and cadaver in two studies have shown noteworthy difference from the measurement of this research [5, 9]. So, limitations of individual research modality should be kept in mind during measurement of the dural venous sinuses.

**Discussion on the dimensions of the transverse sinus**

The mean length of the right and left transverse sinuses showed similarity with the measured length in formalin fixed cadavers [9]. Despite of difference in the measurement modality and procedure, age and sex of the study populations, this similarity in the findings might be due to similarity in the stature in the Bengali and Indian population.

The mean diameters of the right and left transverse sinuses in the present research showed tendencies to be greater than the maximum compared available literature [5, 9, 14]. But the diameters of the transverse sinuses found remarkably less than a cadaver based study [5] but this dissimilarity was may be due to difference in the modality of the research.

**Discussion on the dimensions of the sigmoid sinus**

The mean value of both sigmoid sinus's diameter in the present research showed maximum similarity with the measurement of Kitamura *et al*., (2017) [16] who measured the diameter at the middle of the sinus in the radiological images achieved through angiogram. The measured diameter of the right and left sigmoid sinuses in dried skulls and cadaver showed a large degree of difference with the measured diameters in radiological images [5, 9]. Manual measurement in the anatomical specimens and measurement using software in radiological images might be responsible for this difference.

Through literature review no works had been found on the distance between the transverse-sigmoid junction. There are several clinical conditions such as hydrocephalus, microcephaly, macrocephaly etc. That cause alteration of the normal circumference and diameter of skull. As the transverse and sigmoid sinuses are directly related with skull so, any alteration of diameter and circumference of skull may have a chance to alter the normal morphology of the respective sinuses. In the present research, the distance between transverse-sigmoid junction in normal MRV images was measured so that this baseline data may contribute in the future research regarding the comparisons between normal and diseased population.

**Strengths**

All MRV images of obtained through 3 Tesla magnetic field strength have been collected to clearly identify the continuity and sharpness of the dural venous sinuses. Each individual measurement procedure has been defined with appropriate image in methods. All measurements have been taken two times blindly by the researcher and the co-investigator. Moreover, inter-rater reliability of the measurements has been calculated to magnify the reliability of the data and excellent agreement between the researcher and the co-investigator has been established.

**Limitations**

Regarding the large population of Bangladesh, the total number of participants enrolled in the present research has been insufficient to reach in a definite conclusion. Although in the cerebral MRV images of all the participants were detected as 'normal' but the possibility of existence of undiagnosed disease that may affect the morphology of the dural venous sinuses has not been eliminated. Due to time limitation both contrast and non-contrast (phase-contrast) MRV images were used to assess the variations but these two techniques are not equivalent in assessing the dural venous system. Furthermore, dural venous sinuses enlarge from distal to proximal, so measurement of diameter in a single point of the sinuses could constitute a limitation.

## CONCLUSION

The findings of the present research can contribute to develop a database of adult Bangladeshis regarding the normative measurements of the superior sagittal, transverse and sigmoid dural venous sinuses.

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